CHAPTER

40

Management of Raptors

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Fig 40.1 | Birds of prey have been used for hunting for thousands of years. This practice is believed to have started in Central Asia and its popularity soon spread across the Mogul and Ottoman empires.

The first manuscript in the Arab literature related to raptor medicine, "Benefits of Birds and the Comprehensive Treatment of their Diseases," was written by Adham bin Mahres Al Bahili during the reign of the 4th Caliph Haroon Al Rashid Al Abbasi (765 to 808 A.D.). This was a manuscript comprising 153 chapters in which issues such as diagnoses and diseases were first described. This manuscript was enriched by the participation of Al Hajaj bin Khaytamah during the reign of the 5th Caliph Mohammed Al Amin bin Haroon Al Rashid Al Abbasi (786 to 813 A.D.).

Sadly, there was a crucial hiatus in the continuing contribution of Arab literature to raptor medicine with the Mogul occupation of Baghdad in 1258 A.D. (Fig 40.1). Throughout the succeeding decades, falconry continued to decline in the domains of the Ottomans and Moguls. However, deep into the Arabian Peninsula, Bedouins continued the seasonal traditions of trapping, training and hunting with falcons as a means of supplementing their basic diet.

Falconry is still widely practiced in the Middle East, but is now considered a sport. The large population of falcons maintained annually in captivity prompted the creation of modern medical and research facilities in several countries in the region. These centers have contributed significantly in enhancing our knowledge of raptors during the past 25 years, particularly in falcon medicine (Fig 40.2). Similarly in North America and Europe, dwindling populations of peregrine falcons and bald eagles prompted the creation of rescue and rehabilitation centers and captive breeding programs.

Owing to the need to respond to medical and conservation trends, raptor medicine has become one of the fastest growing disciplines in avian medicine. This has

Fig 40.2 | The saker falcon (*Falco cherrug*) is the most popular species used in the sport of falconry in the Middle East. This species is the largest of the desert falcons. Arab falconers recognize several colors and color patterns for this species. Shown is a much-prized white saker falcon.

Fig 40.3 | The correct way to handle a large raptor is demonstrated on an immature white-tailed sea eagle (*Haliaeetus albicilla*). The towel placed around the body prevents damage to the feathers.

Fig 40.4 | Vultures have strong curved beaks capable of inflicting serious injuries during handling. Only trained personnel provided with suitable equipment (eg, leather gloves and aprons) should handle such birds.

Fig 40.5 | A typical free-flying molting room in the Middle East measures 15 x 8 x 5 m and is provided with red desert sand as a substrate. A single platform-type perch is placed around the room. Some birds have already been released, while others wait on stands until they are settled into the new environment.

been due to the dedication of individuals on both sides of the Atlantic and in the Middle East. This chapter is dedicated to these pioneers who, by their example, have inspired the author over the years.

Capture, Restraint and Transportation

Most raptors kept in captivity have strongly curved upper beaks and long, sharp, curved talons (the exception being vultures). Therefore, only well-trained personnel wearing adequate protective equipment (eg, leather gloves and aprons) should undertake handling and restraint of any of those species (Fig 40.3).

The techniques for capture and restraint vary with the circumstances (Fig 40.4). Birds kept free-flying in aviaries can be captured using nets fitted on long poles and later restrained by hand (Fig 40.5). Many birds are presented to veterinarians in transport crates. The position of the bird should be assessed before introducing the hands and arms into the crate. Make sure beforehand that the bird can easily fit through the door. Never introduce unprotected hands inside a crate holding a raptor. Trained raptors are easy to handle, since such birds are commonly hooded and can be captured on a gloved fist or a perch. The author favors capturing medium to small raptors by hand, then wrapping them with a soft towel to avoid damage to the feathers. Masking tape can be used to secure the towel around the body (Fig 40.6). Two operators should always be involved in the handling of large raptors (eg, vultures, eagles). Commonly, one oper-

Fig 40.6 | Two operators are involved when handling a saker falcon. One technician holds the leash with the gloved hand in case the procedure is aborted, and a second grasps the bird and casts it down on a soft cushion. The falcon is then wrapped with a thin towel to prevent feather damage.

Fig 40.7 | Weighing is an integral part of the medical management of raptors. A technician weighs a saker falcon using an electronic scale accurate to 1 g.

ator places one arm around the wings and holds the bird firmly against his/her body; the second hand holds the legs. While holding the legs, one finger should be placed between the tarsi to prevent lacerations to the skin around the joints. A second operator holds the bird's head and provides further assistance, if required.

Commercially available transport cages used for dogs and cats are suitable for transporting raptors. However, slight modifications such as placing burlap or canvas over grills and attaching pads to the roof of the cage, perches and/or carpet on the floor are all highly recommended measures. Trained hooded raptors usually travel well on perches when the cage is placed in the back of the vehicle or within the cabin of an airplane. During transport, it is highly recommended to protect the tail feathers with a tail guard made of lightweight cardboard or radiology film, fixed to the feathers with masking tape.

CLINICAL EXAMINATION

Clinical examination is similar to that performed on psittacines. The questions related to the clinical history of a bird or a flock can be grouped under three main headings: general clinical details, housing and feeding/watering (Tables 40.1-40.3).

Weighing

Raptors should be weighed upon presentation and regularly thereafter while under medical care. The body weight is a useful measurement in the assessment of health and disease and in monitoring the response to treatment. In addition, the weight of the bird is important for other purposes, such as sex determination, taxonomy or testimony in legal cases. Very often, a trained hooded raptor can be enticed to stand on a scale fitted with a perch. Commercially available electronic scales provided with perching surfaces are recommended (Fig 40.7).

Table 40.1 | General Clinical Details*

- Body weight
- Age
- Sex
- Origin (wild-caught/captive-bred)
- Chief clinical signs
- Duration of disease
- Attitude
- Flight performance
- Frequency and consistency of mutes
- Molting status
- Reproductive status
- Previous medication/treatments

Table 40.2 | Housing*

- Layout of cage/enclosure/aviary
- Size (height, length, width)
- Structural materials (posting, mesh, shade, wind breakers)
- Flooring (substrate)
- Furniture (perches, nesting ledges)
- Feeding and watering utensils
- Location in relation to other aviaries, buildings, roads
- Vegetation in and around aviary
- Proximity of livestock, hay stores, gardening materials
- Companions (number, sex)
- Contact with feral species

Table 40.3 | Feeding/Watering*

- Diet (food items)
- Dietary management (feedings, seasonal changes)
- Food item source, storage and handling
- Appetite
- Water consumption
- Crop emptying time
- Vomition/regurgitation
- Casting

*Modified[76]

Conversely, birds can be placed on a scale while anesthetized or wrapped in a soft towel. Large birds such as eagles and vultures can be weighed together with the handler stepping onto a scale and the weight of the handler subsequently subtracted. The scales' accuracy should be +/- 1% of the body weight of the bird. With raptors used for falconry, the weight of falcon accessories (hood, jesses, bells) has to be taken into consideration. It is paramount importance that the bird be weighed with an empty crop.

PHYSICAL EXAMINATION

In common with other avian species, the physical examination of raptors involves handling and restraint. However, trained hooded raptors can be partially examined on the fist of the handler or while standing on a perch. It is important to carry out a significant part of the physical examination without handling and restraining the bird (Table 40.4). If the bird is a free-living or untrained individual, it will require restraint. Wrapping the bird with a soft towel is always very helpful in avoiding injuries to the main flight feathers. Extreme care should be exercised when examining a raptor. If the bird catches a handler with one or both feet during the handling process (commonly known as being "footed" or "taloned"), it is dangerous to attempt unlocking the grip. In most cases, the best solution is to release the bird. Subsequently, the bird can be recaptured within the room or aviary or recovered back to the glove if the bird is fitted with a leash and jesses.

Endurance Test

The endurance or stress test is very useful in assessing both the health and diseases of the respiratory system of captive raptors. This test can be carried out only on trained, small to medium-sized raptors, eg, hawks or falcons used in falconry. The respiratory rate is first obtained with the bird completely at rest and away from any noise or disturbance. As a general rule, the respiratory rate of a healthy raptor is 20 to 25 respirations per minute. Then, while on the glove, the bird is stressed by letting it vigorously flap its wings for 30 seconds. After this time, the bird is placed back on its perch and is allowed to rest for 2 minutes. The respiration is then assessed based on frequency and nature. After 2 minutes of complete rest, the respiratory rate is again obtained, which, in a healthy hawk or falcon, should be similar to the original prestress rate. Birds with lower respiratory system diseases would show deep, mostly abdominal respiration, with bobbing of the tail and body. The rate might be elevated to 80 to 120 respirations per minute. Radiology, endoscopy and hematology analyses are all highly recommended if a bird fails the endurance test. Examples of other causes of increased respiration following the endurance test include anemia, hyperthermia, septicemia, cardiac disease and ascites.

Table 40.4 | Systematic Examination of Raptors

Anatomical Site	Examination
Eyes and eyelids	Symmetry, appearance, shape, discharge, wounds, swellings
Beak (upper/lower)	Appearance, grooves, cracks, splits, shape
Nares (nostrils)	Symmetry, shape, foreign material (eg, sand), discharge
Oropharynx	Color, swellings, caseous masses, blunted papillae, foreign bodies (eg, bones, tendons, string)
Ears	Symmetry, foreign bodies (eg, sand, ectoparasites), discharge
Neck/crop	Swellings, wounds, impaction
Body (chest and back)	Wounds, swellings, pectoral muscle mass, ectoparasites
Cloaca	Urate/feces seepage, swelling, masses
Wings	Symmetry, wounds, swellings, fractures, feather integrity
Tail	Swellings, feather integrity
Uropygial gland	Size, shape, quantity and consistency of oil
Legs	Symmetry, wounds, swellings, fractures
Feet	Symmetry, grip strength, skin condition, temperature, swellings, wounds, talon condition

Clinical Laboratory Diagnosis

Clinical laboratory diagnosis is an essential component of raptor medicine. In this respect, veterinarians should be aware of the various assays available and be familiar with the protocols for the collection, submission and analyses of samples for the various assays (Table 40.5).

ADMINISTRATION OF MEDICATION

There is a wide choice of routes for the administration of medications to raptors. Each has its own advantages and disadvantages that should be taken into consideration before a particular route is selected (Table 40.6).

Bandages, Dressings and Casts

The placement of bandages, dressings and casts is part of the routine care of injured raptors or part of post-surgical protocols (Table 40.7).

The bandage most widely used among veterinarians working with raptors is a flexible self-adherent bandage[a] that has revolutionized bandaging in veterinary medicine. It should be noted that this material and similar bandages will tighten when wet. Therefore, birds should be kept indoors, and access to open containers of water provided in the cages should be limited or monitored (Table 40.8). For further information on dressing and bandages of raptors, the reader is referred to a recent comprehensive publication.[8]

Foot castings are conforming devices commonly used in raptor medicine to prevent pressure-related trauma to a

Table 40.5 | Diagnostics

Discipline	Specimens	Assays
Hematology	Blood samples for partial or complete hematology analyses	RBC, Hb, PCV, MCV, MCH, MCHC, WBC, differential white cell count, thrombocyte count and fibrinogen estimation
Blood chemistry	Blood samples for partial or complete blood chemistry analyses	Glucose, total protein, albumin, globulin, A:G ratio, urea, uric acid, creatinine, bile acids, ALT (SGPT), ALP, GGT, AST (SGOT), CK, LDH, cholesterol, triglycerides, calcium, sodium, potassium, chloride, ionized Ca, Phos
Parasitology	Biopsies, intestinal content, feathers, fecal samples, skin scrapping, swabs, tissue samples, worms (whole/section)	Direct wet smear, flotation, histology, staining with methylene blue stain, Lugol's iodine, rapid stains
Bacteriology	Aspirates, air sac/tracheal/crop washing, biopsies, swabs, tissue samples	Aerobic and anaerobic cultures, antibiotic sensitivity testing, staining with Gram's stain and Ziehl-Neelsen stain
Mycology	Aspirates, air sac/tracheal/crop washing, biopsies, impression smears, swabs, tissue samples	Fungal culture, clarifying with potassium hydroxide, rapid stains, lactophenol cotton blue, India ink
Serology	Blood samples	Antibody and antigen (eg, ELISA, IFA, PCR)
Virology	Blood samples, tissues, swabs	Embryonated egg culture, cell culture, electron microscopy, PCR
Cytology	Aspirates, impression smears, swabs	Staining with Gimenez stain, Papanicolaou stain, Macchiavello stain, rapid stains
Histopathology	Biopsies, tissue samples	Staining with hematoxylin and eosin stain, periodic acid-Schiff stain, PCR

Table 40.6 | Routes Commonly Used for the Administration of Medications in Raptors

Route of Administration	Site of Administration	Remarks
Oral in water or food	Oropharynx, crop	Raptors do not always drink. It might be possible to hide medication in food.
Oral gavage		Danger of aspiration of medication. Tubes or cannulae with sharp ends should be avoided.
Topical	Eyes, eyelids, ear, oropharynx, crop, skin	Excessive use of creams or ointments might cause matting of feathers; antiseptic solutions and sprays might stain feathers.
Intramuscular	Pectoral muscles, quadriceps muscles	Main choice is pectoral muscles, avoid using long needles; irritant injections might cause muscle damage.
Subcutaneous	Dorsal neck, crural area	When administering a large volume, distribute in different sites.
Intravenous	Jugular vein (right), basilic vein, saphenous vein	Avoid lacerating vein; ensure hemostasis post procedure.
Intraosseous	Proximal tibiotarsus, distal ulna	Placement of intraosseous cannula; efficient in debilitated birds.
Intranasal	Nasal cavities	Avoid irritating substances.
Intrasinal	Infraorbital sinuses	Avoid irritating substances; effective at treating sinusitis through flushing and direct injection.
Intratracheal	Trachea, tracheobronchial syrinx, bronchi	Avoid irritating substances; avoid large volumes.
Inhalation therapy (nebulization)	Upper respiratory system	Effective in the treatment of upper and lower respiratory disease; might lead to environmental contamination.

Table 40.7 | Use and Functions of Bandages

1. Avoid further damage (eg, self-inflicted lesions)
2. Prevent desiccation of tissue
3. Avoid contamination following surgical intervention
4. Holding dressings in place
5. Providing localized pressure to prevent hemorrhage following trauma or surgery
6. Prevent further trauma (eg, fractures)
7. Minimize pain post-surgery
8. Maintain intravenous or intraosseous fluid lines

Table 40.8 | Types of Dressings and Application

Type	Application
Adhesive Dressings	
Transparent dressings[b]	Thin film with a non-latex hypoallergenic adhesive. Allows vapor and oxygen exchange, protects from outside contamination.
Non-Adhesive Dressings	
Hydrocolloid dressing[c]	Adheres to skin but not to wound, creating a gelatinous mass over wound that provides a suitable environment for healing.
Moisture/vapor-permeable dressing[d]	Adequate maintenance of an aerobic environment under the dressing preventing scab formation and promoting epithelialization.
Low-adherent absorbent dressing[e]	Dry dressing with maximum absorbance ideal for infected suppurating wounds.
Petrolatum-impregnated fine mesh gauze[f]	Ideal for large areas of skin damage (eg, abrasion); prevents skin desiccation.

newly created wound in the postoperative treatment of pododermatitis or bumblefoot. Conversely, these can be used to prevent pressure sores to the opposite foot after fracture repair of a leg or to provide comfort during the non-surgical treatment of early bumblefoot lesions. Several materials and designs have been proposed over the years, ranging from a semi-rigid bridge made of thermoplastic tape[g] under the foot, rigid shoes made of styrene plastic polymer,[66] and form-fitting bandages hardened with epoxy glue[70] to a doughnut made of a ring heavily covered with soft bandaging (N.A. Forbes, personal communication). The author prefers to use a soft shoe made from 15- or 20-mm-thick rubber sheet, a material commonly used to make beach sandals. The form of the shoe is cut and shaped with a sharp blade. Round shapes to accommodate the toes and the ball of the foot are made using a red-hot rod. The shoe is fitted to the foot with a light conforming bandage.

Surgery

Many of the surgical procedures and ancillary techniques used in general avian medicine are applicable to raptors (Table 40.9). A short review of the different procedures and the different applications follows. There are other more specific surgical procedures pertinent to raptors and brief descriptions are provided.

KEEL INJURIES

Raptors in general, particularly those used in the sport of falconry, are prone to injuries of the carina, or prominence of the ventral median section of the keel, sustained when they crash on the ground during training exercises with lures or during fights with quarry. The most common type of injury is a longitudinal wound involving the skin and underlying tissue, but sometimes the lateral muscular mass is involved. If the injury is recent, closure should be attempted using conventional surgical techniques; if chronic, dry scabs and fibrous tissue should be debrided. In more severe cases with trauma or osteomyelitis of the carina, debridement of affected bone might be necessary to allow adequate closure.

CLAW DETACHMENT

Most raptors have long, curved talons integrated with a hard, highly keratinized casing covering the dorsal and lateral aspects, and a ventral, much softer plate. Very often, due to excessive length, deformities or trauma, claws can become detached, leading to extensive hemorrhage and exposure of the last phalanx. Intervention should be accomplished as soon as possible to maintain viability of the germinal tissue of the claw. The use of a hydrocolloid dressing[c] and a conforming bandage is indicated. These should be changed every 5 to 7 days. Regrowth of the claw is possible, but this is a slow process sometimes requiring up to 2 to 3 months. Supplementation with 25 μg/kg biotin PO[h] is recommended during the regrowth period.

Distal Necrosis

This term is commonly used to describe necrosis of the terminal ends of the digits. The condition is often associated with extensive scabbing related to pox infection or frostbite. In the Middle East, there is a condition characterized by avascular necrosis of the distal end of the third digit (Fig 40.8). This is more often seen at the end of the hunting season and is very likely associated with cardiovascular changes as a result of a sudden cessation of exercise. A similar theory has been postulated for the development of bumblefoot in raptors.[26,29] Distal necrosis invariably leads to amputation of the digit (Fig 40.9).

Table 40.9 | General Surgical Procedures and Indications in Raptors

Surgery	Indication
Sinusotomy	Removal of trichomoniasis granulomas, draining and flushing in severe obstructive bacterial or fungal sinusitis
Ingluviotomy	Removal of foreign bodies and trichomoniasis granulomas, removal of ingested food in sour crop
Tracheotomy	Removal of aspergillomas and trichomoniasis granulomas from tracheal lumen and syrinx
Celiotomy	Removal of aspergillomas pre- or post-medical treatment
Proventriculotomy Ventriculotomy	Removal of foreign bodies, impaction
Salpingohysterectomy	Removal of uterus and oviduct, sterilization of females
Orchidectomy	Removal of testes, sterilization of males
Vasectomy	Sterilization of males (libido intact)
Cloacopexy	Correction of cloacal prolapse

Table 40.10 | Common Endoscopy Applications in Raptor Medicine*

Application	Anatomical Site
Otoscopy	External auditory canal
Rhinoscopy	Nasal cavities
Pharyngoscopy	Oropharynx
Tracheoscopy	Trachea/tracheobronchial syrinx/bronchi
Ingluvioscopy	Crop
Esophagoscopy	Esophagus
Gastroscopy	Proventriculus, ventriculus
Celoscopy	Coelomic cavity
Cloacoscopy	Cloaca

*Modified[77]

Ring Constriction

This is a condition characterized by an annular or circumferential constriction at a particular area of the toes. The etiology in many cases remains unclear. In the Middle East, ring constriction is very often observed around the hallux or first toe of hunting falcons caused by entanglement with the thin, rope-like jesses used in Middle Eastern falconry (Fig 40.10). Treatment of ring constriction entails the removal of the annular scab and attempted closure with conventional suturing techniques. If suturing is not possible due to a large gap between the wound edges, hydrocolloid dressings[c], together with a conforming bandage changed at regular intervals, is used to achieve healing by granulation and epithelialization (Fig 40.11) (see Chapter 35, Surgical Resolution of Soft Tissue Disorders).

ENDOSCOPY

Endoscopy (*Greek: endon = within, skopein = to examine*) is an essential medical procedure used routinely in raptor medicine as an ancillary technique in the diagnosis of certain medical conditions (eg, aspergillosis, candidiasis) (Fig 40.12), assisting in the collection of

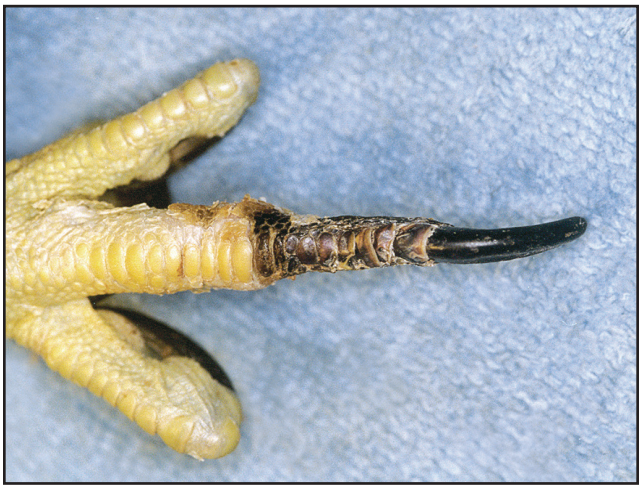

Fig 40.8 | Distal necrosis is a poorly understood condition in raptors. In falcons, the middle digit is most often affected. The etiology might involve vascular disorders originating from a sudden cessation of activity.

Fig 40.9 | Peregrine falcon (*Falco peregrinus*) with a severe self-inflicted injury in the middle digit. This is a common occurrence in newly wild-caught individuals of this species. The damage was extensive, necessitating complete amputation of the digit.

Fig 40.10 | Arab falconers use jesses fitted with a thin cotton or nylon string. This string very often becomes entangled around the hallux or first digit, leading to ring constriction.

Fig 40.11 | Severe ring constriction around the hallux. Satisfactory resolution can be achieved by periodic application of hydrocolloid dressings to the affected area. More severe cases may require surgical reconstruction.

Fig 40.12 | Rigid endoscopes are normally used to examine the upper digestive tract of raptors under anesthesia. Candidiasis and esophageal trichomoniasis are two of the diseases diagnosed with the aid of endoscopy.

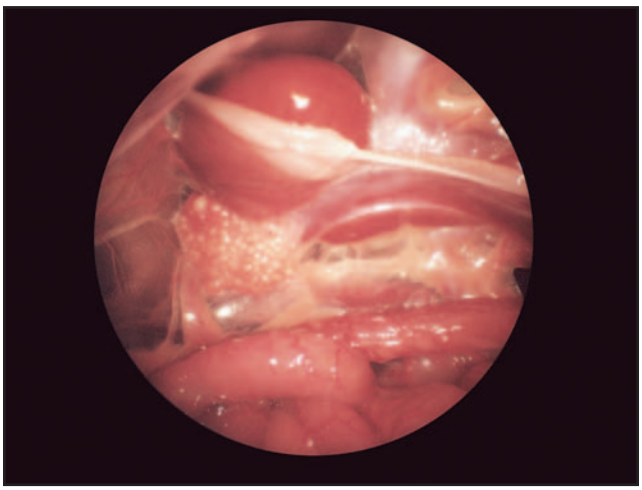

Fig 40.13 | Endoscopic view of the reproductive tract of an immature bird. Endoscopy offers the opportunity to examine the organs directly for signs of health and disease and to collect biopsies.

Fig 40.14| Fracture of the tibiotarsal bone in a saker falcon. This is the most common type of fracture encountered in clinical practice with captive raptors. Fractures of this bone tend to occur in newly tethered birds and during training exercises.

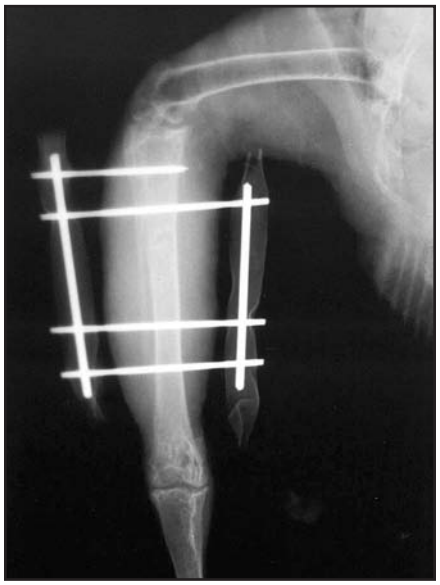

Fig 40.15 | The bird in Fig 40.14. The fracture was repaired using a shuttle pin and a type II external skeletal fixator. Two acrylic bars and additional metals pins within the tubing were used to maintain the fixator in position and provide extra strength.

Fig 40.16 | A similar fracture of the tibiotarsus in a gyr-peregrine hybrid falcon. This fracture was repaired using an intramedullary pin inserted in a normograde fashion from the tibial crest, a positive profile threaded pin placed distally and tie-in using a bar and clamps.

Fig 40.17 | The falcon in Fig 40.16. Note the bandage covering the external skeletal fixator and the shoe placed on the opposite foot to prevent bumblefoot. In uncomplicated cases, full healing should be expected in 4 to 6 weeks.

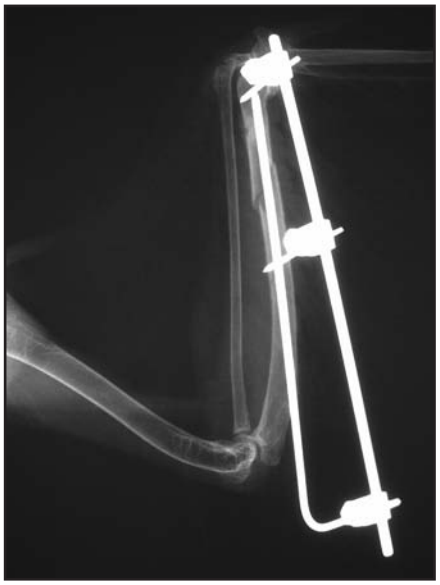

Fig 40.18 | Oblique fracture of the distal ulna repaired using an intramedullary pin inserted in normograde fashion from the proximal ulna, two positive profile threaded pins placed in the proximal and distal fragments, and tie-in using a bar and clamps.

Fig 40.19 | Fracture of the first phalanx of digit 2 in a saker falcon. There was extensive soft tissue swelling and lysis of the bone fragments requiring amputation of the digit.

biopsies (eg, liver biopsy) and assisting in the performance of some intracoelomic surgical interventions (eg, vasectomy) (Fig 40.13, Table 40.10) (see Chapter 24, Diagnostic Value of Endoscopy and Biopsy).

ORTHOPEDIC SURGERY

Raptors are very often presented to rescue and rehabilitation centers with luxations and fractures[62] caused by inadequate management, trapping, injuries by larger migratory raptors and collision with moving vehicles or stationary objects (eg, fences, towers, utility poles) (Figs 40.14-40.17). The goal of return to flight and the associated need for retention of soft tissue and joint integrity make orthopedics in raptors destined for either

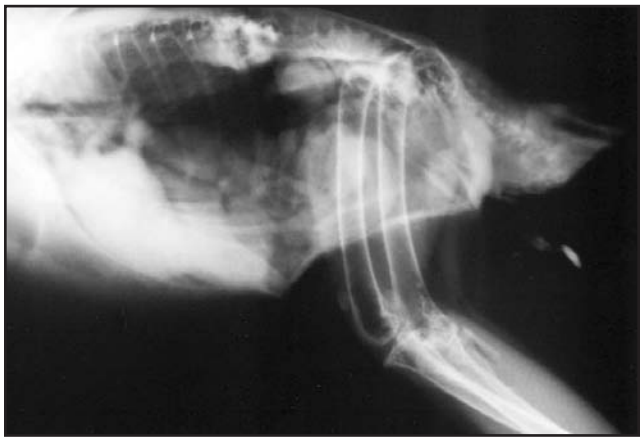

Fig 40.20 | Lateral radiograph of a falcon showing extensive osteoarthritic changes of the vertebral synsacral joint. The only clinical sign was the inability to maintain a straight position while standing. Damage tends to occur due to collision-type injuries.

falconry or release a different proposition than it is for pet psittacines. Table 40.11 summarizes orthopedic techniques used in raptor medicine (Table 40.11, Figs 40.15-40.20). For further information, the reader is referred to published information.[25,62,64,72] (See Chapter 34, Surgical Resolution of Orthopedic Disorders).

Pododermatitis

Pododermatitis or bumblefoot is a common medical condition of captive raptors and is characterized by inflammation and often abscessation of the sole of the foot or the plantar aspect of the digits. This condition appears to be caused by a combination of factors including poor nutrition, obesity, inadequate perches, lack of exercise, poor blood circulation to the foot and cardiovascular changes at the end of the hunting season[26,29] (Figs 40.21, 40.22). Some raptor species appear to be more susceptible to this condition than others. For instance, the incidence of bumblefoot appears to be higher in falcons but

Table 40.11 | Techniques for Fracture Repair in Raptors[62]

Anatomical Site	Technique
Coracoid	Conservative treatment (eg, immobilization of the wing).
Humerus Proximal	Tension band technique. Two Kirschner wires driven normograde cross-pin fashion, tension band formed by cerclage wire.
Mid-shaft	Intramedullary pin type I external skeletal fixator tie-in technique. Steinmann intramedullary pin normograde fashion driven from the distal end of the humerus. Placement of two positive profile threaded pins, one in the dorsal condyle, and the second placed close to the curvature of the pectoral crest. Tie-in with a fixator bar and clamps[i], thermoplastic tape[g] or acrylic bar[k].
Distal	Intramedullary pin type I external skeletal fixator tie-in technique. Two Kirschner wires driven normograde cross-pin fashion, placement of a positive profile threaded pin[i], on the curvature of the pectoral crest. Tie-in with a fixator bar and clamps[i], thermoplastic tape[g] or acrylic bar[k].
Radius and Ulna	"Figure eight" coaptation bandage. Intramedullary pin type I external skeletal fixator tie-in technique. Normograde placement of Steinmann intramedullary pin, normograde fashion driven from the proximal end of the ulna and Steinmann intramedullary pin normograde or retrograde fashion in the radius, placement of two or more positive profile threaded pins tie-in with a fixator bar and clamps, thermoplastic tape[g] or acrylic bar[k].
Major Metacarpal	Coaptation with splint[f] or thermoplastic tape[g] splints. Intramedullary pin type I external skeletal fixator tie-in technique. Steinmann intramedullary pin or Kirschner wire in normograde or retrograde fashion, placement of two or more positive profile threaded pins tie-in with thermoplastic tape[g] or acrylic bar[k].
Femur Proximal	Tension band technique. Two Kirschner wires driven normograde cross-pin fashion, tension band formed by cerclage wire.
Mid-shaft	Intramedullary pin type I external skeletal fixator tie-in technique. Steinmann intramedullary pin retrograde fashion, placement of two or more positive profile threaded pins tie-in with a fixator bar and clamps, thermoplastic tape[g] or acrylic bar[k].
Distal	Two Kirschner wires driven normograde cross-pin fashion, placement of a positive profile threaded pin on proximal femur. Tie-in with a fixator bar and clamps, thermoplastic tape[g] or acrylic bar[k].
Tibiotarsus	Intramedullary pin type I external skeleton fixator tie-in technique. Steinmann intramedullary pin normograde fashion driven from the tibial crest, placement of a positive profile threaded pin distally tie-in with a fixator bar and clamps, thermoplastic tape[g] or acrylic bar[k].
Tarsometatarsus	Type II external skeletal fixator. Placement of four pins, tie-in with fixator bar and clamps, thermoplastic tape[g] or acrylic bar[k].

Fig 40.21 | Plantar view of the foot of a saker falcon showing a large area of dry skin in the center of the sole. The adjacent papillae are flattened, having lost the form and texture due to the use of inadequate perches and lack of exercise.

Fig 40.22 | The foot in Fig 40.21. The dry skin was removed by brushing gently, exposing underneath an early ulcerative lesion in the skin. This is, in the author's opinion, the most common presentation of bumblefoot in captive raptors.

Fig 40.23 | Severe bilateral bumblefoot in a saker falcon, with soft tissue swelling and underlying infection. Such cases are not amenable to treatment due to large skin deficits that remain after scab removal. The use of skin flaps has been attempted with little success.

seldom occurs in hawks.[26] In most cases, the preferred therapy involves the surgical removal of scabs and adjacent necrotic and purulent tissue, followed by suturing to achieve healing by first intention (Fig 40.23). The placement of antibiotic-impregnated polymethylmethacrylate beads within the newly created cavity improves the rate of healing.[69] If the skin deficit is relatively large and complete closure is not possible, partial closure might be attempted with a purse-string suture together with hydrocolloid dressings[c] to promote healing by second intention. The use of foot casting together with conforming bandages as part of the postoperative treatment is highly recommended (see previous section on foot casting) (Fig 40.24).

IMPING

Imping, a medieval falconry term, is the art of repairing fractured or bent feathers. The integrity of the primary and tail feathers is of the utmost importance for flight and performance in raptors destined for release back into the wild or for those used in the sport of falconry. Feathers tend to suffer severe bends or fractures during captivity in rescue and rehabilitation centers (poor aviary or holding cage design), training or hunting (crash landings or fighting with quarry) or because of inadequate handling and transport (no tail guard). Imping is usually carried out by total or partial feather replacement or by external splinting[45,78,89] (Fig 40.25). See Table 40.12 for a list of materials used for imping.

For a total and partial feather replacement, it is necessary to procure a feather that is of the same species, side (eg, wing feather), size, sex, age and color. Rescue and rehabilitation centers and medical facilities concerned with raptors usually maintain a collection of molted feathers and feathers obtained from carcasses. It is recommended to carry out feather examination and feather repair procedures under general inhalant anesthesia.

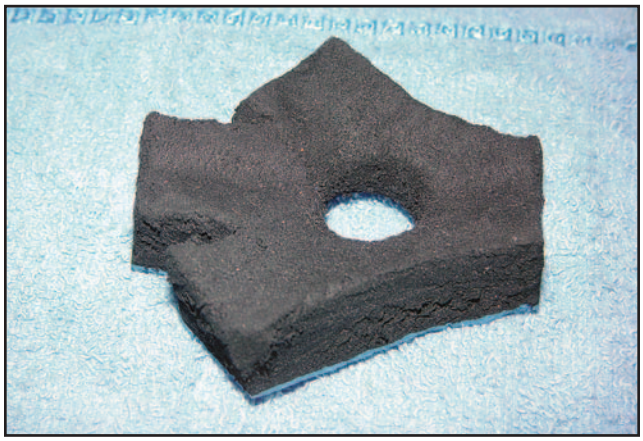

Fig 40.24 | A custom-made protective shoe made from a soft rubberized material. These are used to protect surgical sites in the sole of the foot and to prevent pressure sores on the opposite foot after orthopedic surgery.

Fig 40.25 | Materials and equipment required for feather repair and total or partial feather replacement.

Table 40.12 | Materials and Instruments for Imping

- Scissors, small, sharp, fine-pointed
- Nail cutter, medium and large (eg, cat and dog size)
- Imping needles, made from steel hairpins, long 50 mm x 1.5 mm, medium 40 mm x 1.5 mm, short 30 mm x 1.5 mm, fine 25 mm x 1 mm
- Hair clips (aluminum) 100 mm long
- Nail file, fine
- Methacrylate glue
- Epoxy glue, fast setting
- Baking soda, finely powdered
- Pliers, curved, fine-tipped
- Bamboo pegs, different diameters (barbecue skewers are ideal)
- Knife, interchangeable blades
- Cardboard cards, thin, 5 cm x 5 cm square

Total Feather Replacement

Total feather replacement is indicated when the feather is fractured at the proximal section of the feather shaft. After examination and determining the number of feathers for

Fig 40.26 | This falcon sustained a fracture of a tail feather with complete loss of the fragment. The fracture occurred in the first third of the shaft, requiring full feather replacement.

Fig 40.27 | A similar feather was procured and cut to the same size as compared with the feather on the opposite side of the tail. A pre-made short bamboo peg was placed between the two fragments and glued into position using rapid-setting epoxy glue.

Fig 40.28 | Tail of the falcon in Figs 40.26 and 40.27, showing the new feather in place. In addition, the two deck or central feathers were repaired using the partial replacement technique.

Fig 40.29 | This saker falcon has suffered fractures of primaries 1st, 2nd and 3rd (8th, 9th and 10th according to the Western ornithology) with loss of feather fragments. Partial feather replacement is indicated in this particular case.

repair, the area should be prepared. First, the covert feathers are deflected backward and held in place with masking tape to expose the base of the shaft. The fractured feather is cut approximately 15 to 25 mm from the skin with a nail cutter (Fig 40.26). The new feather is placed in position to assess the length, making sure to maintain bilateral symmetry with the opposite wing when replacing a wing feather, or the opposite side if replacing a tail feather. If the feather from the opposite side is missing, the veterinarian or technician should follow the feathering pattern of the wing or tail characteristic of the species (eg, in a peregrine falcon, primary 10 [No 1 in Arab falconry] is approximately 5 to 8 mm shorter than primary 9 [No 2 in Arab falconry]). This general ornithological knowledge is essential to carrying out feather replacement adequately. The feather is cut, and a bamboo peg about 80 to 100 mm long is prepared by sharpening both ends to approximate the diameter of the shaft of the new feather and the empty shaft of the wing. The wooden peg is first glued into the shaft of the new feather with fast-setting epoxy. Additional glue is then placed (eg, injected with a 1-ml tuberculin syringe) into the shaft, making sure the feather is properly aligned. A small piece of cardboard should be placed under the imping site to prevent the glue from smearing onto adjacent feathers (Fig 40.27). The wing or the tail should then be closed in the natural anatomical position and all the feathers held in place with hair clips until the glue is set (Fig 40.28).

Partial Feather Replacement

Partial feather replacement is indicated if the fracture has occurred at the mid-shaft or at the distal end of the feather. If a fracture is complete and the feather fragment

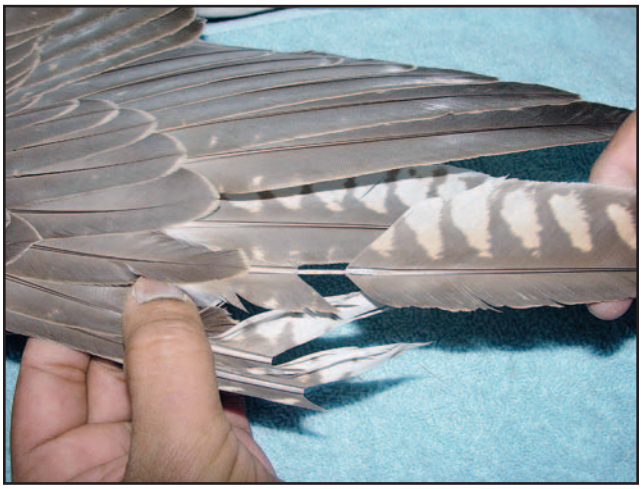

Fig 40.30 | Feather fragments from the same species, size, side (eg, left wing), sex, age and color have to be procured. Imping needles of a suitable size are used to join the fragments. The needle is first fixed into the distal fragment using methacrylate glue. The fragment is then pre-placed into the fractured fragment to check alignment before gluing into position.

Fig 40.31 | The falcon in Fig 40.30 with the three feathers repaired. It is highly recommended to place an external splint as that described in Figs 40.32 and 40.33 to reinforce the ventral aspect of the imping surface. The dorsal aspect can be filed to produce a smooth surface and then colored using a brown marker.

Fig 40.32 | A severe bend in the mid shaft of a main flight feather. Note that the integrity of the feather shaft has been maintained.

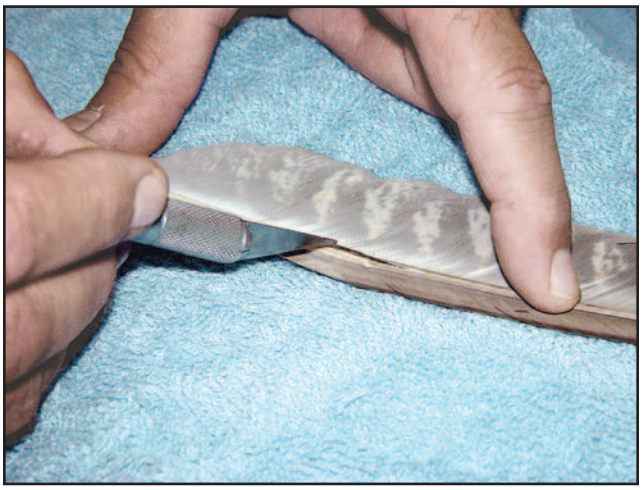

Fig 40.33 | The preliminary stage of the technique used by the author for feather repair involves splitting the ventral aspect of the shaft, 12 to 15 mm in either direction from the bend, using a sharp knife.

is missing, a similar fragment must be procured from a donor feather (Fig 40.29). Conversely, the fragment might then be reattached. In both cases, the ends of the fragments are smoothed out with a fine-pointed scissor and a fine nail file. A previously prepared imping needle of suitable length and diameter is carefully inserted in both fragments to make a narrow channel. The needle is then fixed onto the fragment with a small amount of methacrylate glue. The fragment is attached onto the rest of the feather and checked for correct alignment. Additional glue is then applied onto the free end of the needle of the fragment, which is then attached to the rest of the feather (Fig 40.30). Pressure should be applied over the imping site with fine-tipped, curved hemostats or pliers for approximately 30 seconds to allow the glue to set. The dorsal and ventral aspects of the fracture line are then filed with a fine nail file. In partial replacement, it is strongly recommended to apply a ventral external splint in addition to the method described above to produce a more satisfactory and efficient result. The dorsal aspect of the imping site can be colored, if necessary, with a marker pen (Fig 40.31).

Bent Feather Repair

Moderate or severe bending might occur at different levels of the shaft. Bends are repaired using the external splinting technique. The bend is straightened on its dorsoventral axis with a pair of fine-tipped, curved hemostats or pliers (Fig 40.32). The ventral aspect of the feather shaft is then split 12 to 15 mm in either direction from the bend (Fig 40.33). A suitable imping needle is placed in the newly created groove and secured firmly

Fig 40.34 | The second stage of this technique involves the placement of an imping needle within the newly created groove. Methacrylate glue is then used to secure the needle into position.

Fig 40.36 | After completing the splint, fine-grain nail files are used to smooth the newly created surface. The final product blends very well with the shaft of the feather, resulting in a satisfactory cosmetic repair.

with methacrylate glue (Fig 40.34). The ventral surface of the feather shaft around the bend is roughened with a fine nail file. A thin layer of methacrylate glue is smeared onto the site approximately 10 mm to either side of the bend. A small amount of baking soda is sprinkled directly onto the freshly glued surface (Fig 40.35). The sodium bicarbonate binds with the glue creating a strong cement-like layer over the bend. The procedure can be repeated two or three times to create a thicker layer if this proves necessary. The upper surface and the edges of the newly created layer are filed with a fine nail file (Fig 40.36). The external splint is translucent, making the need for coloring unnecessary.

COPING

Coping is a medieval term meaning the trimming and reshaping of talons and beak. Overgrown talons and

Fig 40.35 | The final stage of feather repair involves the creation of an external splint using a combination of methacrylate glue and sodium bicarbonate to produce a cement-like layer over the original bend.

Table 40.13 | Materials and Instrumentation for Coping

- Nail cutter, guillotine-type
- Nail cutter, large, human-type
- Nail file, fine
- Methacrylate glue
- Baking soda, finely powdered
- Knife, interchangeable blades
- Silver nitrate pencil

beaks are commonly found in captive raptors due to the insufficient wear associated with the use of soft, inadequate perching surfaces and lack of a natural diet. More severe cases indicate malnutrition. See Table 40.13 for a list of materials used for coping.

Talons

Knowledge of the size and morphology of the talons of different raptor species is essential. Overgrown talons are best trimmed with a guillotine-type nail cutter. The talon is then reshaped with a sharp blade and nail files. Excessive trimming would invariably lead to hemorrhage. The use of a thermocautery or a silver nitrate pencil is usually sufficient to arrest any hemorrhage. The use of a lanolin or paraffin-based hand cream is recommended after trimming and reshaping of the talons. Raptors used in the sport of falconry should have the talons trimmed before placing them into molting chambers (Fig 40.37).

Beak

In raptors, the shape of the beak is species-specific. For instance, *Buteo* spp. and *Accipiter* spp. possess a hooked beak design for tearing at prey, while the beak of *Falco* spp. has a tomial tooth used presumably to sever the head of prey. Knowledge of the normal

Fig 40.37 | Overgrown and deformed talons are the result of the use of inadequate perching surfaces. The talons of the hallux are more susceptible to deformities if birds are confined to small round perches such as the Arab-style stand.

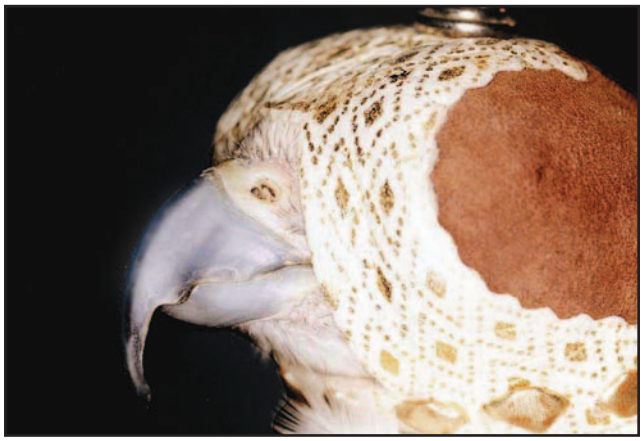

Fig 40.38 | Saker falcon with a long deformed beak after the molting season. Coping, an old medieval term, is the art of trimming and reshaping of the beak and talons of raptors. Coping of the beak is usually carried out using nail cutters and fine-grain nail files.

Fig 40.39 | Severe bilateral splitting of the upper beak with lateral deviation of the lower beak in a peregrine falcon due to neglect. The coping of such a condition requires several sessions over several months to fully correct the different defects.

Fig 40.40 | Deep unilateral groove in the beak of a saker falcon. This condition commonly originates from scratch injuries sustained at the anterior aspect of the nares, damaging the germinative tissue of the beak and leading to a growth disorder.

morphology of beaks in raptors is essential before undertaking any reshaping.

An overgrown beak is simply trimmed back with human-type nail cutters, and the tip reshaped with nail files or a rotary grinding tool (Fig 40.38). The lateral aspect of the beak of captive raptors is prone to cracks and fissures, which can be prevented by providing hard surfaces (stones) where the bird can both clean its beak and file it regularly to maintain its shape. Cracks and fissures should be trimmed as soon as possible to prevent more serious conditions such as fractures (Fig 40.39). Lateral grooves on one or both sides of the beak are found commonly in raptors, but particularly in falcons (Fig 40.40). It has been suggested that these grooves in falcon beaks are due simply to old age. An alternate explanation, adhered to by this author, involves the grooming practices of falcons. During routine grooming, falcons tend to scratch the head with their talons. Puncture wounds to the eyes or scratches to the eyelids and the nares are often observed. During scratching, a falcon can easily hook a talon on the anterior aspect of the nares causing a laceration. This wound is created on the edge of the germinative tissue of the beak, creating a groove as the beak grows. Very little can be done to correct this condition. Temporary filling of the defect with methacrylate glue and baking soda or commercially available beak repair kits has been successful. However, as the beak grows, continuous repairs will be required every 8 to 12 weeks.

HOSPITAL CARE

In order to be treated for selected medical conditions, raptors must be hospitalized (Fig 40.41). Free-living raptors usually tolerate small cages, provided these are fitted with curtains and maintained in quiet, semi-dark rooms. Falconry birds can be kept unhooded on wall or floor perches. Hoods are commonly used only during

Fig 40.41 | Large raptors can be kept in small, secluded aviaries during hospitalization. This griffon vulture (*Gyps fulvus*) was admitted for the treatment of a compound fracture involving the humerus.

routine cleaning and for handling purposes. Hospitalized raptors should be fitted with a tail guard as described in the earlier section on capture and restraint.

Handling of raptors for medication administration and cleaning should be kept to a minimum; non-intrusive cages with a tray fitted below a slatted floor are ideal. Furthermore, a significant amount of medications can be administered hidden in food (eg, tablets or powdered medication inside the heart of a quail). There are cases, however, in which medication has to be administered by injection, nebulization or topically, and handling is therefore necessary. Hooded raptors are easier to maintain under hospital conditions. Changeable substrate (eg, carpeting, sand, newspaper) under floor or wall perches allows easy maintenance of such birds. The administration of medicaments to such birds also is facilitated, since hooded raptors can, for instance, be given intramuscular injections in the chest musculature by a single operator without restraint.

DIET AND FEEDING STRATEGY

Hospitalized raptors can be fed a variety of food items such as feathered and unfeathered quail, mice, rats, ducklings, rabbits, day-old chicks and fish for species such as ospreys (*Pandion haliaetus*) and bald eagles (*Haliaeetus leucocephalus*). Thiamine supplementation at a rate of 2 mg/kg PO weekly is indicated when using frozen-thawed fish. The daily provision of casting material in the form of fur and feathers is of the utmost importance. Casting material should be offered only to raptors in which the gastrointestinal tract is working normally. However, raptors very often refuse to eat, and it might prove necessary to force-feed them in order to meet their daily nutritional requirements. For a list of materials used to force-feed raptors, see Table 40.14. For a complete description of dietary management of captive raptors, the reader is referred to comprehensive previously published accounts.[3,61]

Table 40.14 | Force-feeding Materials

- Stomach tube, blunt end, plastic (5 mm, 8 mm or 12 mm in diameter)
- Feeding syringe, 60 ml
- Lubricant[l]
- Formula container

Table 40.15 | Force-feeding Formula[e]

Formulae	Ingredients	Instructions
Formula 1 - Induction	Add 15 ml water to 20 g ground whole unfeathered quail +10 g ground beef or chicken liver + ¼ teaspoon glucose-electrolyte preparation in powder form[m].	Administer 20 to 30 ml of mix per kg body weight, 3 or 4 times daily during first day of admission.
Formula 2 - Intensive	Add 20 g of ground whole unfeathered quail +10 g ground beef or chicken liver +1 whole egg + ¼ teaspoon glucose-electrolyte preparation in powder form[m].	Administer 30 to 40 ml of mix per kg body weight, 3 or 4 times daily; weigh daily, until the desired body weight is reached.
Formula 3 - Maintenance	Add 5 ml water to 20 g of unfeathered ground quail + 10 g ground beef liver + ¼ teaspoon glucose-electrolyte preparation in powder form[m].	Administer 30 to 40 ml of mix per kg body weight, 3 or 4 times daily; weigh daily.

Force-feeding is the introduction of nutritional formula into the alimentary tract by means of a stomach tube, and injected using a large syringe. There are several commercially available diets that can be used. However, the author favors the force-feeding diets and feeding strategy for raptors shown in Table 40.15. In fish-eating species, fish can be incorporated into the diet by substituting it for the quail, beef or chicken.

To force-feed a raptor, the thoroughly lubricated feeding tube is passed gently into the back of the oropharynx, through the crop and then into the esophagus toward the right side of the neck. Great caution should be exercised while manipulating the tube within the crop to avoid folding the tube or causing a penetrating wound through the crop wall. During force-feeding, the neck of the bird should remain extended to discourage regurgitation. Feeding tubes and syringes must be thoroughly washed, disinfected and rinsed (1 ml quaternary ammonium and biguanadine compounds disinfectant[n] in 500 ml water for 2 to 5 minutes) prior to using them on another patient.

BIOSECURITY

Biosecurity is defined as a series of measures undertaken within a building or building complex to prevent the propagation and spread of diseases. Housing a large

Fig 40.42 | Disinfection is the backbone of any biosecurity program. The technician is using a fogging unit loaded with a solution of commercially available disinfectant[n] within a falcon room. Note that the procedure is being carried out in the presence of the birds.

number of raptors (eg, captive breeding program) within the same facility represents a potential risk if basic biosecurity rules are not followed. The risk becomes more significant when there is a constant flow of raptors from different origins such as hospitals or rescue and rehabilitation centers. For instance, an epornitic outbreak of pox within a facility housing 15 different species of raptors was reported in the USA. The author has observed similar outbreaks of pox and Newcastle disease in falcon molting and breeding facilities in the Middle East. In some cases, outbreaks of Newcastle disease were traced to the consumption of infected quail and pigeons. In other instances, pox and Newcastle disease were traced to affected falcons placed in close contact with healthy birds without having gone through a quarantine period.

One of the main pillars of any biosecurity program is disinfection. Disinfection is defined as a procedure intended to eliminate from a particular defined area any pathogenic organism or to render them inert with one or a combination of chemicals. There are many products available on the market that could be used within a biosecurity program. Such products should be non-toxic, non-irritating, non-corrosive and, ideally, biodegradable. Once a suitable product has been obtained, the next step is to design and implement a disinfection program for the facility (Fig 40.42).

The disinfection program followed at the Fahad bin Sultan Falcon Center facilities in Riyadh, Kingdom of Saudi Arabia (Table 40.16) is based on the use of a recently introduced quaternary ammonium and biguanadine compounds disinfectant[n].

Table 40.16 | Disinfection Protocol (using F10 disinfectant)[n]

Area	Applications	Frequency	Dilution
Reception			
Walls	Spray and wipe clean	Weekly	1:500
Counter	Spray and wipe clean	Twice a day	1:250
Floor perch	Spray and brush	Twice a day	1:250
Waste bins	Spray inside of new bin liner	Daily	1:250
Floors	Sweep clear, apply with mop	Daily, twice a day	1:500
Air space	Fog	Weekly	1:125
Air conditioning filters	Spray and leave to dry	Weekly	1:250
Examination rooms/Operating theatre			
Walls and cabinets	Spray and wipe clean	Twice a week	1:250
Door handles	Spray and wipe clean	Twice a day	1:250
Worktables and sinks	Spray and wipe clean	Twice a day	1:250
Examination table	Spray and wipe clean	After each use	1:250
Towels	Soak overnight, wash	Daily	1:250
Equipment	Handles and switches, spray and wipe clean	Daily	1:250
Trolleys	Spray and wipe clean	Daily	1:250
Telephones, light switches	Spray and wipe clean	Daily	1:250
Waste bins	Spray inside of new bin liner	Daily, twice a day	1:250
Floors	Sweep clear, apply with mop	Daily, twice a day	1:500
Floor drains, sink wastes	Pour solution down drain	Weekly	1:500
Air space	Fog	Weekly	1:125
Air conditioner filters	Spray and leave to dry	Weekly	1:250
Post-mortem room			
Carcass fridge	Wash out with water, spray and leave to dry	After defrosting	1:250
Safety cabinet, table	Wash out with water, spray and leave to dry	After each use	1:250
Hospital/Quarantine/Molting wards			
Rooms	Fog	Weekly	1:125
Carpeting, artificial turf tops	Spray, brush down surfaces and perches	Daily, twice a day	1:250
Water bowls	Wash, soak	Daily	1:250
Walls and cabinets	Spray and wipe clean	Weekly	1:250
Door handles	Spray and wipe clean	Twice a day	1:250
Worktables and sinks	Spray and wipe clean	Weekly	1:250
Examination table	Spray and wipe clean	After each use	1:250
Equipment	Handles and switches, spray and wipe clean	Daily	1:250
Trolleys	Spray and wipe clean	Daily	1:250
Telephones, light switches	Spray and wipe clean	Daily	1:250
Waste bins	Spray inside of new bin liner	Daily, twice a day	1:250
Floors	Sweep clear, apply with mop	Daily, twice a day	1:250
Floor drains, sink wastes	Pour solution down drain and wastes	Weekly	1:500
Air space	Fog	Weekly	1:125
Footwear decontamination	Spray or use footbath	Before and after using	1:250
Air conditioner filters	Spray and leave to dry	Weekly	1:250

Infectious Diseases

Infectious diseases are those disorders produced by the invasion and propagation of microorganisms in body tissues. Infectious diseases may produce no clinical signs, or they may cause a myriad of reactions, including localized cellular injury due to competitive metabolism, toxins, intracellular replication or antigen-antibody response. Infectious diseases can be divided into four main groups: Parasitic, bacterial, viral and fungal diseases.

PARASITIC DISEASES

Parasites (*Greek*: *Parasitos*) are organisms that live upon or within other living organisms, at the hosts' expense. Parasites are often found associated with free-living and captive raptors. The relationship between the parasite and its host does not necessarily translate into overt disease. However, both intrinsic (eg, severe weight loss, immunosuppression, toxicosis, collateral infectious disease) and extrinsic (eg, heat stress) factors can exacerbate the effect of parasites, resulting in adverse clinical signs.

In general, parasites can be classified as ectoparasites (*Greek: ecto = outside*) and endoparasites (*Greek: endon = inside*). However, in the context of this chapter, the main parasites of raptors will be described under the grouping macroparasites (arthropods, helminths) and microparasites (protozoa, hematozoa).

Macroparasites

Arthropods

Arthropods or ectoparasites are invertebrates commonly found associated with the integument of free-living and captive raptors.[29,42,92] All ectoparasites of raptors are classified under the phylum Arthropoda, classes Insecta and Arachnida, and include mainly ticks and mites (Acarina), fleas (Siphonaptera), larvae of flies and louse flies or hippoboscids (Diptera) and chewing lice (Phthiraptera, formerly Mallophaga).[42] Some species of ectoparasites (eg, lice, mites) live permanently on the host while others (eg, ticks, flies) only temporarily (Table 40.17).

For more information on geographical distribution, pathogenesis and suggested control of ectoparasites in raptors, the reader is referred to excellent reviews recently published.[42,92,109]

The treatment used by the author for the control of ectoparasites in raptors is an insecticide containing 1.25 g/L permethrin, 6.25 g/L piperonyl butoxide and 20 mg/L methoprene[o]. This is sprayed lightly under the wings, over the neck and back, and under the tail. Meticulous cleaning and spraying of the rooms, cages or aviary might be required.

Table 40.17 | Common Ectoparasites Found in Raptors

Hard ticks	*Ixodes ricinus, I. arboricola, Hyalomma marginatum, H. rufipes, Rhipicephalus turanicum, Amblyomma lepidum*
Soft ticks	*Argas persicus, A. reflexus, Ornithodoros* spp.
Mites	*Dermanyssus gallinae, Ornithonyssus sylviarum, Knemidokoptes mutans, Kurodaia haliaeeti, Bonnetella fusca, Boydaia falconis*
Fleas	*Echidnophaga gallinacea, Ceratophyllus gallinae*
Larvae of flies	*Lucilia* spp., *Calliphora* spp., *Prosimulium* spp., *Carnus hemapterus, Passeromyia heterochaeta*
Louse flies	*Ornithomya avicularia, Pseudolynchia canariensis, Icosta Americana, Ornithomya anchineuria*
Lice	*Craspedorrhynchus* spp., *Aegypoecus* spp., *Laemobothrion tinnunculi, Degeeriella rufa, D. discocephala stelleri, Falcolipeurus* spp. *Kelerinirmus rufus camtschaticus, Caracaricola chimangophilus, Pterophilus sudanensis, Colpocephalum zerafae*

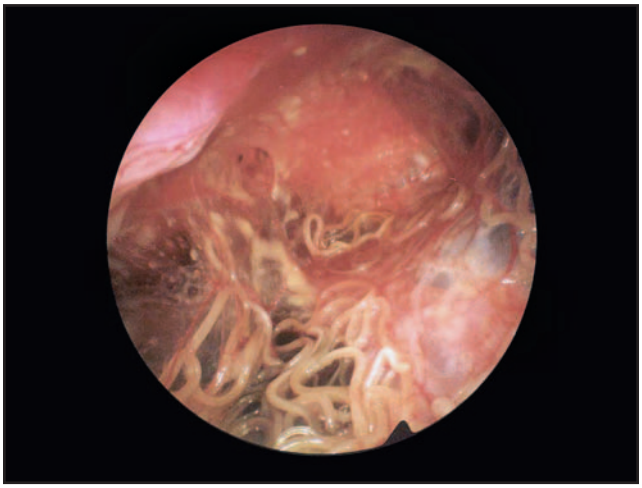

Fig 40.43 | Large number of *Serratospiculum seurati* filarial worms within the coelomic cavity of a saker falcon. Falcons often carry a heavy parasitic burden without displaying any clinical signs. However, the falcon depicted in this photograph had severe air sacculitis and associated dyspnea.

Helminths

Helminths (*Greek: Helmins = worm*) are a group of parasitic worms with various structural and behavioral characteristics that inhabit different organ systems of raptors. These can be classified under the following groups: trematodes (flukes), cestodes (tapeworms), nematodes (roundworms) and acanthocephalans (spiny-headed worms).[44]

It is generally believed that large numbers of certain parasites can coexist within the host without posing any serious health threat. For instance, exceedingly large numbers of *Serratospiculum seurati* filarial worms have been observed within the coelomic cavities of recently caught free-living saker falcons upon routine endoscopy in the Middle East[85] (Fig 40.43). The endoscopic examinations were carried out as an integral part of health assessments. In most cases, finding such heavy parasitic burdens was incidental and did not correlate with any obvious clinical signs. However, in severe infections, *S. seurati* has been found associated with pneumonia, air sacculitis and early lesions of aspergillosis.[85]

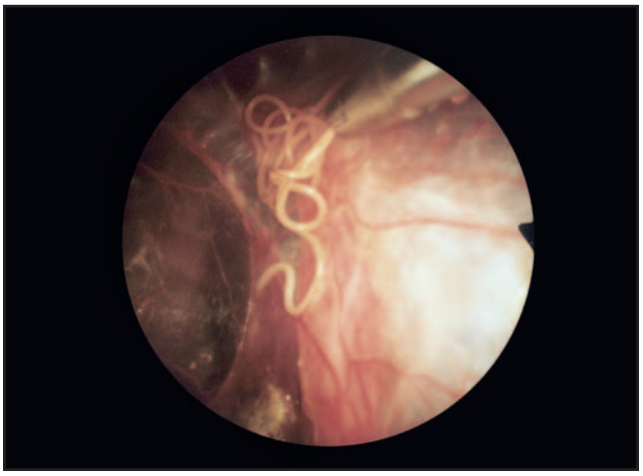

Fig 40.44 | It is a common and widespread practice to manually remove *Serratospiculum seurati* filarial worms from the coelomic cavity following ivermectin treatment. This is unnecessary in most cases as the worms are commonly absorbed. The current treatment of choice for serratospiculiasis is 1 mg/kg PO q7d x 2 weeks of moxidectin.

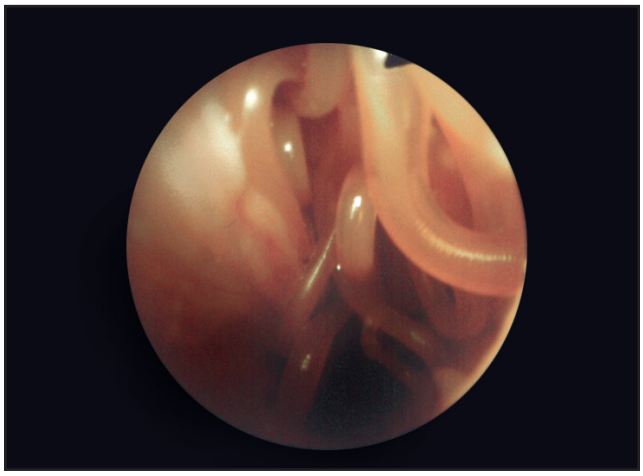

Fig 40.45 | Adult *Physaloptera alata* worms attached to the esophagus of a lanner falcon (*Falco biarmicus*). This was an incidental finding during a routine endoscopy examination of the upper digestive tract. The ova of this species are very similar to those of *Serratospiculum seurati*, but differ slightly in size and shape.

It is a good practice to screen captive birds for parasites a minimum of two times a year. This should be part of a much wider preventive medicine program. When possible in captive breeding projects, up to three fecal samples should be collected at intervals of 24 to 48 hours to provide a better qualitative and quantitative assessment of the presence of parasites. It is imperative to educate raptor owners and keepers to the fact that the treatment of parasites involves more than administering pharmacological compounds. Other important aspects of parasitic control include strict hygiene measures and modifications to aviaries and enclosures to prevent access to intermediate hosts (eg, placement of pebbles as substrate in open aviaries to prevent raptor's access to earthworms).

The following table (Table 40.18) provides a list of the most common endoparasites of raptors. For further information on the taxonomy and distribution of endoparasites in raptors, the reader is referred to a comprehensive and excellent review recently published.[44]

Table 40.18 | Common Endoparasites Found in Raptors

Trematodes	*Clinistomum complanatum, Nematostrigea serpens, Neodiplostomum attenuatum, Strigea falconis, S. falconispalumbi*
Cestodes	*Anomotaenia mollis, Cladotaenia globifera, C. armigera, C. cylindracea, Hymenolepis exilis, Idiogenes flagellum, Matabelea fuhrmani, Mesocestoides perlatus*
Nematodes	*Baruscapillaria falconis, Capillaria tenuissima, C. falconis, C. contorta, C. strigis, Cyathostoma americana, C. brodskii, C. lari, Diplotrianea falconis, Eucoleus dispar, Porrocaecum angusticolle, P. depressum, Serratospiculum seurati, S. tendo, Serratospiculoides amaculata, Syngamus trachea, Synhimantus laticeps, S. hamata, Physaloptera alata, Procyrnea leptoptera, P. mansioni, Tetrameres accipiter*
Acanthocephalan	*Centrorhynchus aluconis, C. buteonis, C. globocaudatus, C. kuntzi, C. olssoni, C. robustus, C. spinosus, C. tenuicaudatus, Mediorhynchus armenicus, M. papillosus*

Treatment

Praziquantel is widely used for the treatment of trematodes and cestodes at the dose rate of 50 mg/kg PO or SC as a single dose.[97] Alternatively, niclosamide at the dose rate of 125 mg/kg PO also as a single dose has been used for the treatment of cestodes. The author, however, currently is successfully using a compound mixture[p], providing a total of 10 mg/kg PO praziquantel, for the control of trematodes and cestodes in falcons, administered in two doses 1 week apart. In addition, this compound provides 10 mg/kg oxfendazole. The pharmacological action of oxfendazole on nematodes in raptors has not been ascertained. Fenbendazole, at the dose rate of 25 mg/kg PO for 3 to 5 consecutive days, is used very commonly for the treatment of nematodes in raptors.[29,47,96] Levamisole has been recommended for the treatment of nematodes in raptors at the dose rate of 10 to 20 mg/kg PO for 2 consecutive days.[47] Alternatively, fenbendazole at the dose rate of 25 mg/kg PO for 5 consecutive days has been suggested.[29] Ivermectin also has been widely used for the treatment of nematode infections, in particular those involving *Serratospiculum seurati*[46,85] in the Middle East. Ivermectin at the dose rate of 200 μg/kg IM or SC has been used to stunt the parasites and allow subsequent surgical removal of adult worms.[46,85] However, doses of up to 3 mg/kg IM have been suggested for the control of *S. seurati* infections in hybrid gyrfalcons.[46] The author, in common with other clinicians, has found that ivermectin at the dose rate of 2 and 3 mg/kg IM or SC can lead to temporary blindness lasting up to 48 hours in saker, peregrine, Barbary (*Falco pelegrinoides*) and lanner falcons.[85] The author favors the use of moxidectin[p] at the dose rate of 1 mg/kg

PO q7d x 2 weeks, for the treatment of *Serratospiculum seurati*, *Capillaria falconis*, *Physaloptera alata* and acanthocephalan infections in falcons (Figs 40.44-40.45).

Microparasites

Protozoa

Trichomonas gallinae is perhaps the single most important protozoan affecting raptors worldwide. The disease, known in falconry terminology as frounce, is typically characterized by the appearance of caseous lesions in the upper digestive system, including the tongue, oropharynx, crop and esophagus[93] (Fig 40.46). Trichomoniasis also can affect the upper respiratory tract of raptors, affecting the nasal cavities, the infra-orbital sinuses, the trachea and the tracheobronchial syrinx.[79,93] Carnidazole[q], at the dose rate of 20 mg/kg PO[10] to 120 mg/kg PO[100] as a single dose, has been used in the treatment of clinical trichomoniasis in raptors. Conversely, metronidazole can be used at the dose rate of 50 mg/kg PO SID for 5 consecutive days.[93] Currently, the author uses metronidazole[r] at a higher dose, 100 mg/kg PO for 3 consecutive days, in the treatment of trichomoniasis in falcons, as this appears to be more effective (Figs 40.47-40.52).

Several different species of coccidia of the genera *Caryospora*, *Eimeria*, *Sarcocystis* and *Frenkelia* (Table 40.19) are relevant in raptor medicine.[42,44] Species of the genus *Caryospora* appear to be the more pathogenic to raptors, particularly to young birds under captive conditions. Weight loss, reduced appetite, regurgitation and vomiting, blood in feces, diarrhea and acute death characterize clinical coccidiosis.[19] Similar clinical signs, together with poor performance during training exercise, have been frequently observed by the author in captive falcons in the Middle East, particularly in juvenile peregrine, Barbary and lanner falcons. The treatment of choice for coccidiosis is toltrazuril[s] 25 mg/kg PO.[40] This product is known to have a bitter taste and tends to induce regurgitation in a significant number of raptors immediately after administration. The author administers toltrazuril with a crop cannula to falcons at this dose rate, mixed 1:1 with a cola-based soft drink to mask its bitter taste, for 2 consecutive days. The incidence of regurgitation is significantly reduced with this method.

Table 40.19 | Common Microparasites of Raptors

Coccidia	*Caryospora kutzeri, C. boeri, C. henryae, C. falconis, C. megafalconis, C. neofalconis, C. uptoni, C. buboni, Frenkelia microtis, F. glareoli Sarcocystis cernae, Eimeria accipitris, E. asturi*
Hematozoa	*Haemoproteus tinnunculus, H. brachiatus, H. elani, H. nisi, H. janovyi, H. syrnii, Plasmodium elongatum, P. fallax, P. circumflexum, P. lophurae, P. relictum, P. vaughani, Leucocytozoon toddi, L. ziemanni, Trypanosoma bramae, T. noctuae, T. santodiasi, T. syrnii, T. avium, T. fiadeiroi, T. guyanense, T. langeroni, T. everetti, T. fiadeiroi, T.corvi*

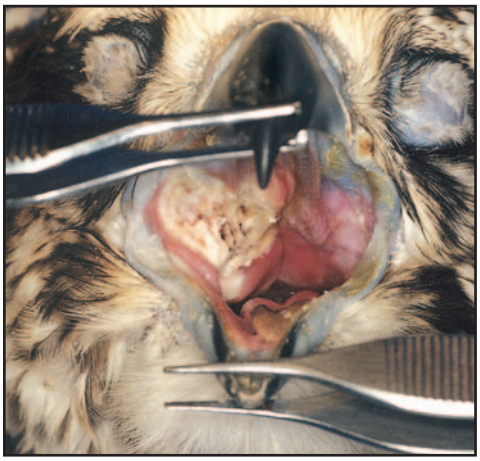

Fig 40.46 | A large caseous lesion produced by infection with the protozoan *Trichomonas gallinae* in the lateral oropharynx of a saker falcon. Infection usually occurs when captive raptors are fed pigeons or doves. Raptors living in urban or suburban areas are prone to contract trichomoniasis because they have access to feral populations of pigeons.

Hematozoa

Hematozoa (*Greek: haima = blood, zoa = animals*) are protozoan parasites living in the blood. The most relevant species in raptor medicine (Table 40.19) are classified under the genus *Haemoproteus*, *Leucocytozoon*, *Plasmodium* and *Trypanosoma*.[42,44,59] There appears to be a relatively high incidence of some hematozoa in free-living birds. In a recent survey, up to 11% of 976 Falconiformes and up to 13% of 173 Strigiformes were found positive for hematozoa in Germany.[43] The impact of these hemoparasites on their host is not well understood. In general terms, it is believed that the pathogenicity of most hemoparasites for raptors is relatively low. However, hematozoa infections have been directly implicated in severe clinical disease and even the deaths of individuals. It has been shown that infections with *P. relictum* can cause severe clinical disease in gyrfalcons, while several deaths in nestling owls have been attributed to *Parahaemoproteus*[101] spp. and *Leucocytozoon* spp. infections.[32] In addition, the deaths of a sub-adult saker falcon[91] and a common kestrel (*Falco tinnunculus*)[56] were attributed to severe hypochromic anemia produced by heavy parasitic infections of *Babesia shortti*.

Suggested treatment for hematozoa includes the use of chloroquine[t] at the initial dose rate of 25 mg/kg PO, followed by 15 mg/kg at 12, 24, 48 hours together with primaquine[t] at the dose rate of 0.75 mg/kg PO.[29,31]

BACTERIAL DISEASES

There are numerous bacterial diseases that have been described in different species of raptors worldwide. A brief description is therefore included here of the most

Fig 40.47 | Unilateral trichomoniasis infection in the nasal cavity of a saker falcon. The caseous mass is bulging through the palate. This type of infection very often leads to moderate to severe obstruction of the nasal cavity and difficulty eating. Note the food debris accumulated at the cranial aspect of the palate. In extreme cases, this condition could lead to a fistula formation between the oral and nasal cavities.

Fig 40.48 | Severe unilateral trichomoniasis infection affecting the supraorbital region of a saker falcon. The infection usually enters through the supraorbital diverticulum of the infraorbital sinus. Note the large, multiple caseous masses bulging through the skin.

Fig 40.49 | The same falcon as in Fig 40.48 after treatment and 2 weeks after surgery. The falcon was administered metronidazole for 3 consecutive days and an antibiotic for 7 days, after which time the caseous masses were surgically removed.

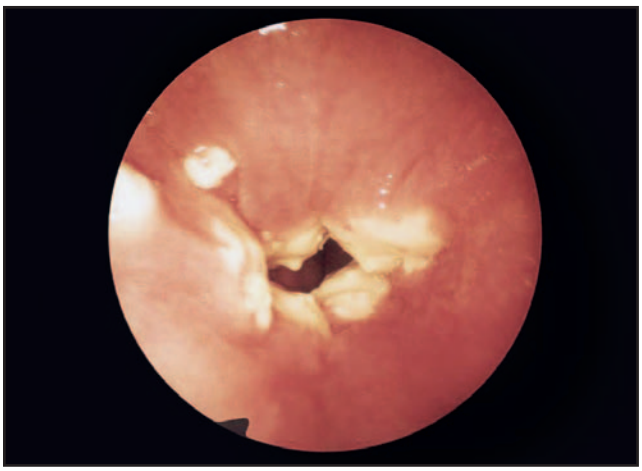

Fig 40.50 | Multiple nodular trichomoniasis lesions at the cranial aspect of the thoracic esophagus as seen from the crop. The masses had created a virtual ring, producing stenosis. The growths were not palpable from the crop, therefore illustrating the need to examine the upper digestive tract by endoscopy in selected cases based on the clinical history.

Fig 40.51 | An extreme case of trichomoniasis infection in a saker falcon. The appearance in this falcon is misleading, as it gives the impression that it had just eaten and has a full crop.

Fig 40.52 | A dorsoventral radiograph of the same falcon as in Fig 40.51, clearly showing a single large caseous mass within the crop. In most cases, masses such as this can be retrieved through the oropharynx after a course of antiprotozoal therapy.